Small Engine Repair

ACTIVITY GUIDE

For a Briggs & Stratton Model 12H302 Four-Stroke Engine
Quantum 120000 Series)

Developed by:

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Overview:

Objectives	**In this module the student will:** • Identify the theory, uses and operation of small gas engines. • Explore engine operation using the four-stroke and two-stroke cycle principles. • Develop knowledge of proper and safe tool usage. • Interact with the mechanical, electrical and fuel systems of a small gas engine. • Complete the disassembly and reassembly of a small gas engine.

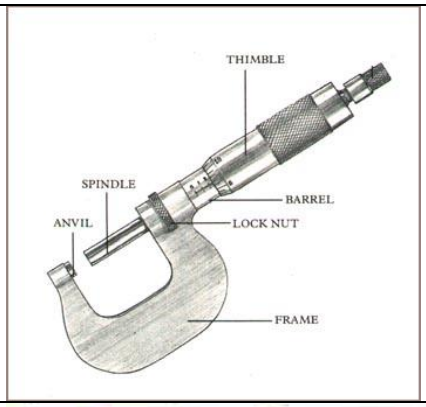
Required Items	All of the required tools and equipment you will need to complete this module are available from your teacher. Tools Module book Computer/Internet Access Book: Care & Repair (By Briggs & Stratton) Digital Camera

Activity 1: Tools Check List

Assignment 1:

Find the Toolbox, and do an inventory using the handout sheet. When you have completed the inventory, call your instructor over and show him/her where each item is located. He may quiz you on where they may be used.

Socket Set	Most of the loosening of bolts on the engine will be done with sockets. **(see illustration on next page)** ☐ All Metric & SAE sockets ☐ Spark Plug Socket ☐ Ratchet ☐ Socket Extensions ☐ Flywheel Nut Socket	 Basic Socket Set
Wrenches	A Set of Wrenchs – A wrench can sometimes reach places that can't be reached by a socket. ☐ Metric Wrenches ☐ Imperial Wrenches	
Hammer	You may need to loosen a part (like the flywheel). Only use a RUBBER hammer to hit an engine part. ☐ A soft rubber hammer	
Safety Glasses	There are some steps (such as removing the valve springs that require safety glasses). SAFETY FIRST! ☐ Safety glasses	

0 - 3" micrometers	**Micrometer** - This tool is used to measure engine parts that are can be affected by wear (such as the cylinder bore or piston) This is used when the greatest precision is required down to 1/10,000 of an inch. ☐ Micrometer Size Range: _____	
Telescoping Gauge – Up to 3"	Telescoping gauges are used along with the micrometer to measure the diameter of the cylinder. (Use the gauges and then measure the gauge with the micrometer) ☐ Set of 5	
Feeler Gauges - Up to 0.35	Feeler Gauges are for measuring the gap in the spark plug and distance between the magneto and the flywheel. They measure very small spaces precisely. ☐ Set	
Valve spring compressor	This tool compresses the valve springs so the valves can be removed. ☐ Spring Compressor	

Piston Ring Compressor	This tool compresses or squeezes the rings on the piston so the piston tapped back into the cylinder. ☐ Piston Ring Compressor	
Gear Puller	The flywheel is fitted on a tapered shaft and that tapper makes it difficult to remove the shaft even when the nut is removed. This tool helps pull the flywheel off the shaft. ☐ Gear Puller	
Torque Wrench	It looks similar to the ratchet in a socket set. It is used for bolts that have to tightened with a specific amount of force. ☐ Torque Wrench	

Socket Set

Deep Sockets

Reducers

Socket Extension

1/2” Ratchet

3/8” Ratchet

13/16” Spark Plug Socket

15/16” Flywheel Nut

Activity 2: Small Gas Engines

Although the first internal combustion engine was invented in 1680 (by a Dutchmen), it was the 1900s before they became inexpensive enough to become widespread.

An internal combustion engine uses the energy from an explosion (of gasoline and air) in the cylinder to turn a shaft (that power a mower blade, or, wheels).

An engine changes chemical energy (the fuel explosion), into mechanical energy (the turning of the shaft).

Many improvements have made engines lighter, cheaper, more efficient, and more environmentally friendly.

Source:
http://www.themotorreport.com.au/6915/the-real-mccoey-on-ron-research-octane-number

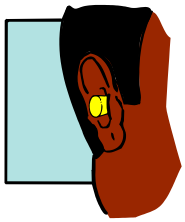
Assignment 2: Engine Developments

Use the book: ***Small Engine Care and Repair*** to answer these questions.

1. Starting in 1920, Briggs and Stratton became one of the most innovative engine designers. We should get an idea how much they contributed to the development of engines. (see page 7 of the book)
    a. Which Model of engine did Briggs & Stratton first invent for lawn mowers and other small applications back in the 1920s?
    b. What big development occurred at Briggs & Stratton in 1953 that made engines lighter and easier to use?
2. There is a gas powered clothes machine machine on p. 7. Why would anyone have bought one of these in the early 1900's ?

Activity 3: Safety

General Safety Considerations



We have less safety precaustions than normal because:

- We will not be starting the engine.
- We have removed the gasoline & oil/lubricants from the engine to protect you and your clothes

Safety instructions

☐ Wear safety glasses when removing and inserting the value springs.

☐ Use the tools in the way they were designed to be used.

☐ Don't fool around

If you were going to work on an engine at home, it's important that you know the proper safety rules to keep you safe

.

Assignment 3:

List the **11** "**Safe Maintenance**" points and **7** "**Protecting Your Health**" points on page 13 of ***Small Engine Care & Maintenance.***

Activity 4: Preparing for Disassembly

You will be removing 20 components off the engine in the next activity. Each component has bolts or small parts that can't be lost.

Assignment 4:

Construct a storage method with **20** compartments. (Probably 2 of these - like in the picture) The sections should be constructed so small pieces can't slide into another section.

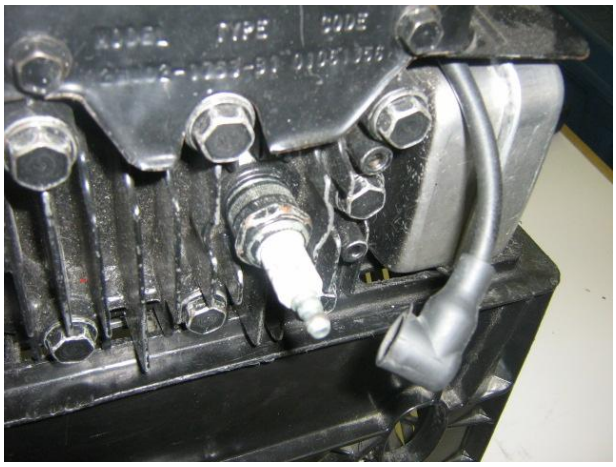
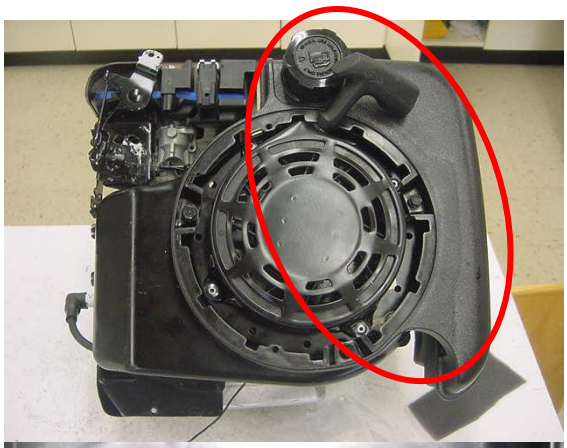
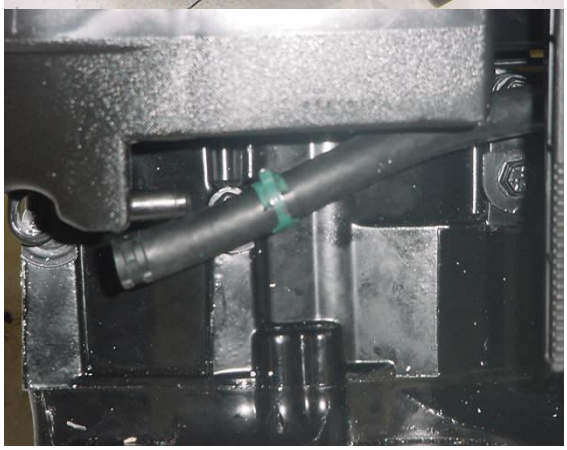
(boxes will be in the Garbage bin or check with the custodian)

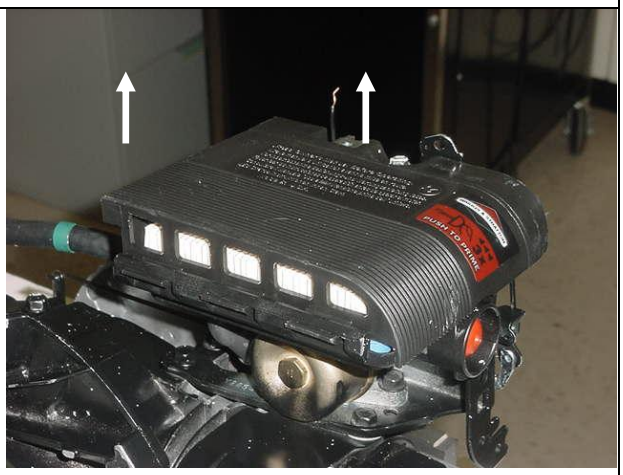
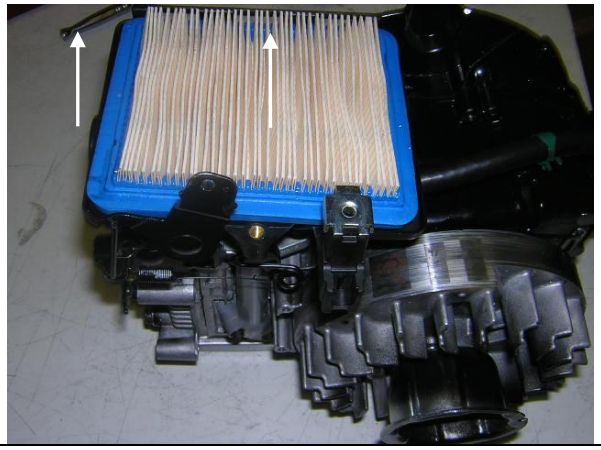
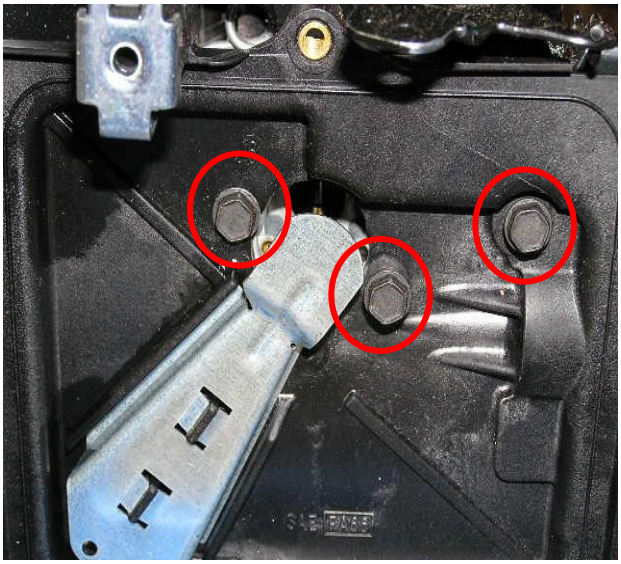
Purpose: Put the pieces in your storage compartment in the order of disassembly. Re-assemble the engine by taking pieces out in the reverse order.

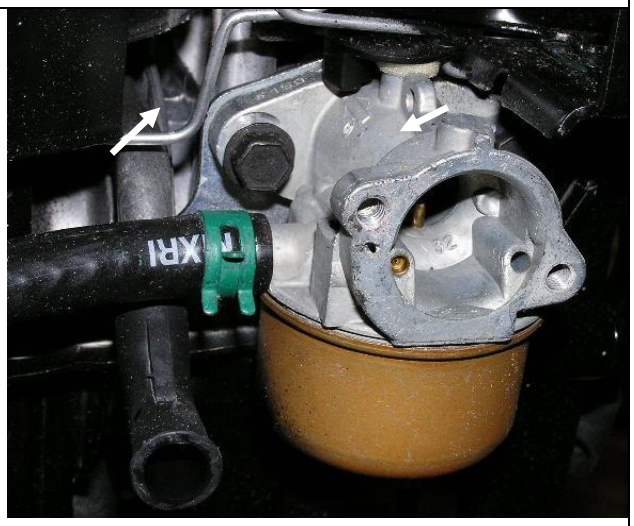
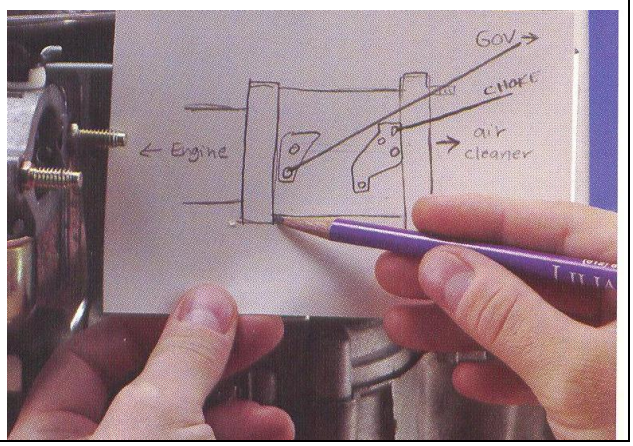
Show this system to the instructor before going on.

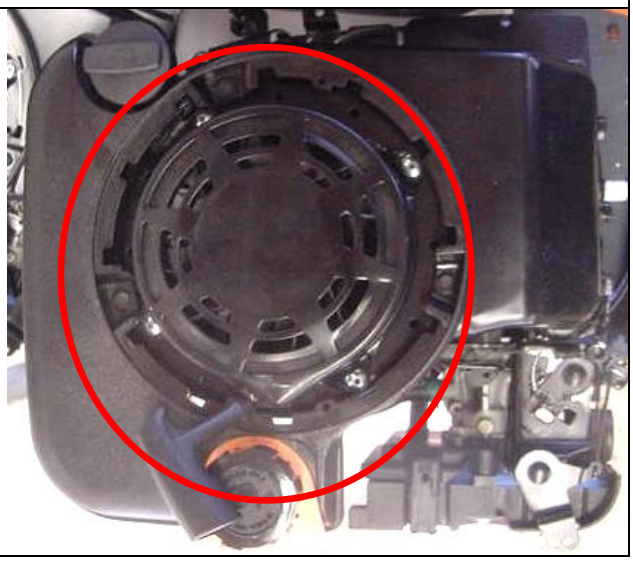
Activity 5: Disassembly

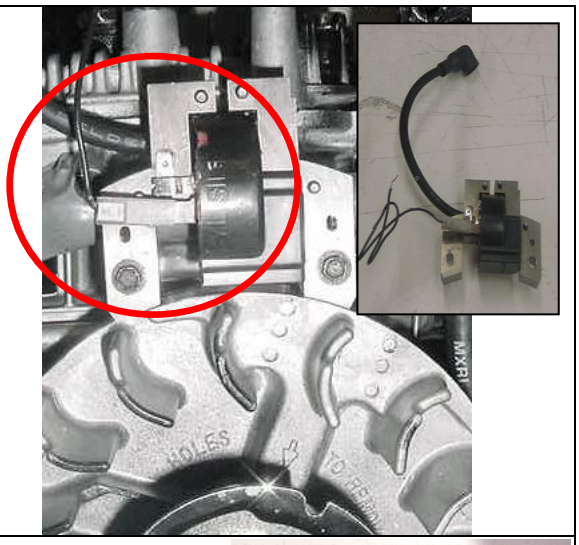
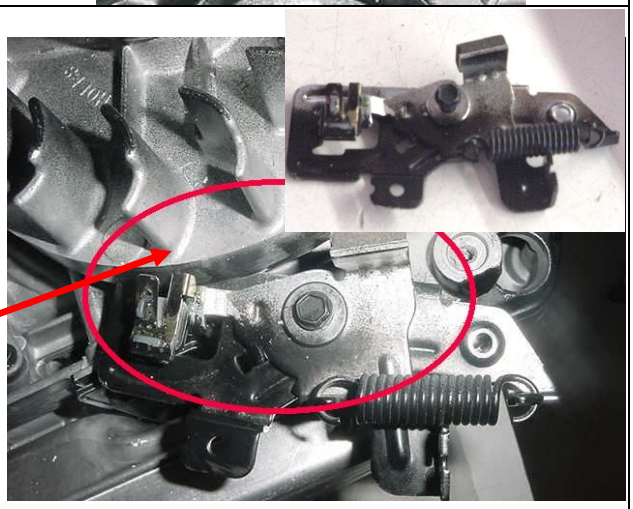
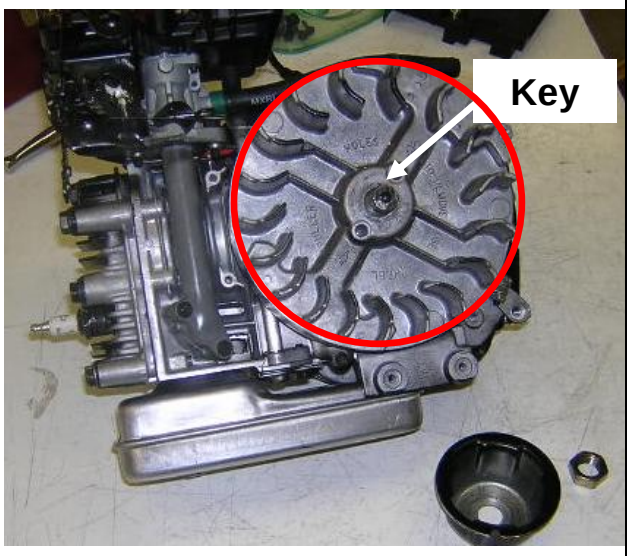
Have your instructor assign you an engine that you can start to disassemble.

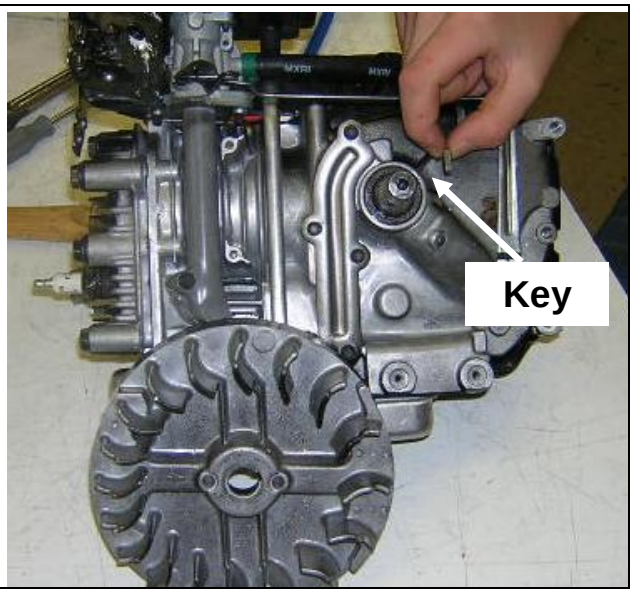
Step	Remove Spark Plug & Fuel Tank	
1	**Spark Plug Wire:** This wire connects the coil to the spark plug. Never touch it while the engine is running, you might get a shock). Removing the spark plug wire can be accomplished by pulling the cap straight up off the spark plug. DO NOT PULL THE WIRE. Use a socket wrench to remove the spark plug.	
2 3	**Fuel Tank**: Remove 3 bolts that attaches the fuel tank to the block. . **(7/32 socket)** **Oil Dip Stick:** There is one screw holding the dip stick. Then, pull up on it to remove it from the hole. Put this screw with the other ones from the gas tank. Disconnect one end of the **Fuel hose** from the fuel tank. Use pliers to squeeze the hose clamp and slide it up the hose. Then, twist the hose side to side while pulling from the tank. Now the tank should lift off easily.	 

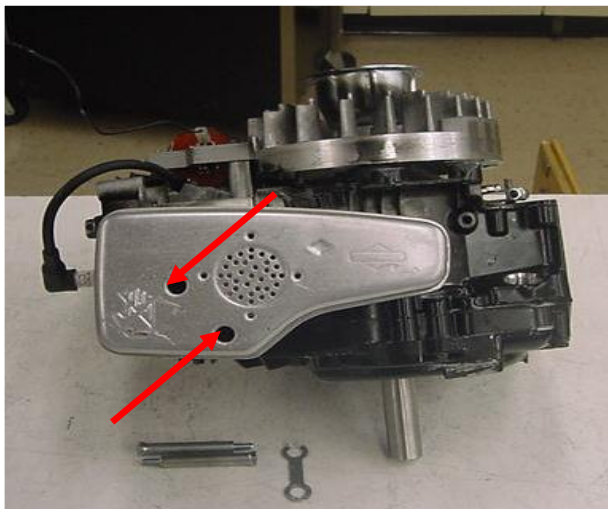
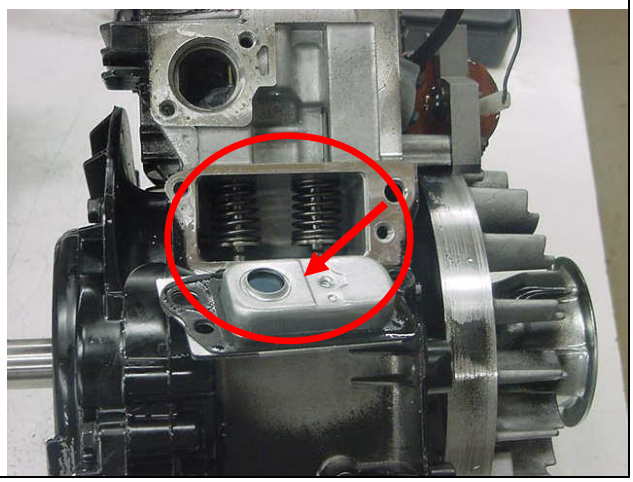
Step	Remove Air Filter	
4	**The Breather:** This filters the air going in the carburetor. Dirty air will plug up the carburetor. Remove the top cover of air breather filter by removing one screw and folding the cover down.	
5	**Air Filter**: Remove air filter	
6	**Air Breather Assembly:** Remove lower breather assembly (3 screws).	

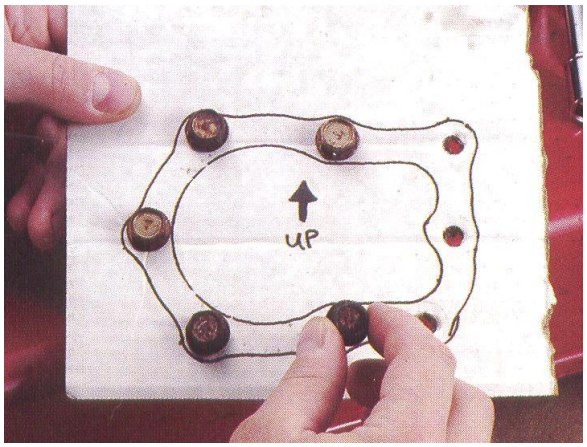
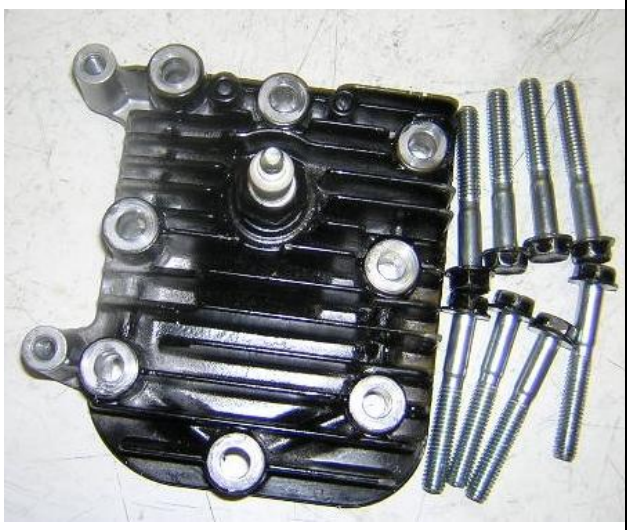
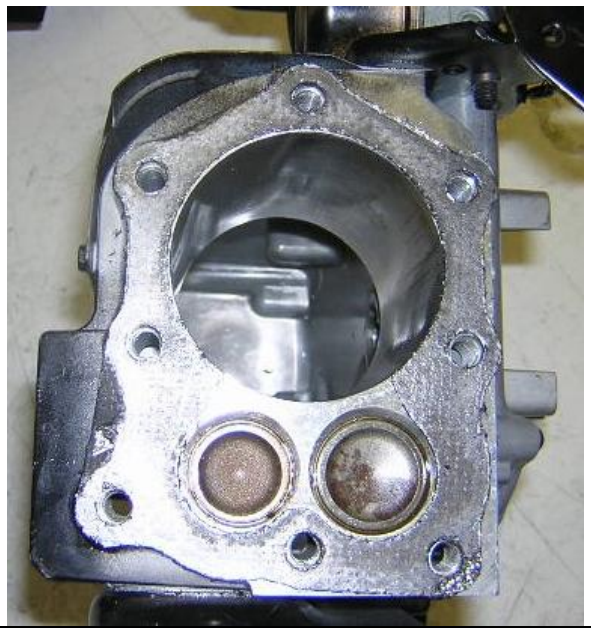
Step	Remove Carburetor	
7	**The Carburetor:** The carburetor mixes the fuel with the air. Remove 2 bolts attaching the carburetor to the engine. **(3/8 socket)** You can leave the fuel line attached if you wish.	
note	**Note:** On the top of the carburetor, there are a couple of springs. You need to note their position before removing the carberator. One goes to the choke and other one is the governor spring. **Draw a sketch that will remind you where these are located**.	

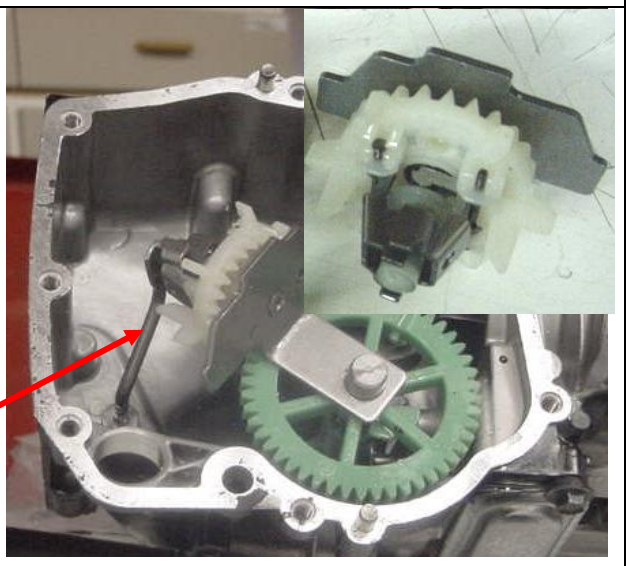
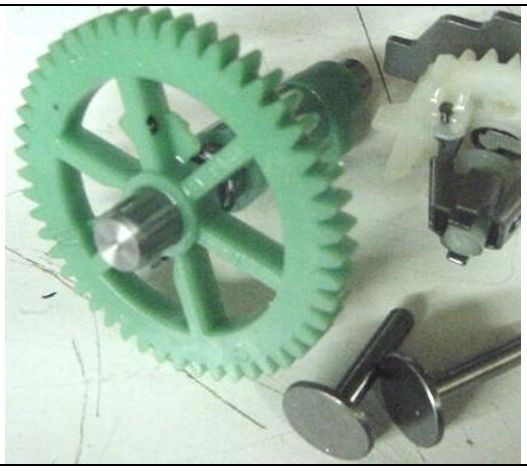
Step	Remove Starter Assembly	
8	**Starter Assembly:** Better known as the pull chord, this manually rotates the engines until it starts. Remove 4 bolts securing starter assembly to the engine and remove starter assembly. **(3/8 socket)**	

9	**Coil / Ignition Armature:** The coil creates the electrical energy that creates the spark in the sparkplug. Unhook the wire from back of coil and remove the coil. **(7/32 socket)**	
10	**The Engine Break**: It shuts off the engine when the safety handle is released. (For example, when you start a lawn mower, you have to hold a handle down or else the mower will stop). **(5/16 socket)** Remove the engine brake by removing two screws. **This may not be present!**	
11	**Flywheel:** The flywheel cools the engine as it spins around. Remove 1 bolt holding the flywheel using a **15/16 socket**. Continued… Tap the shaft/fly wheel with a rubber hammer or use the gear puller tool. 	

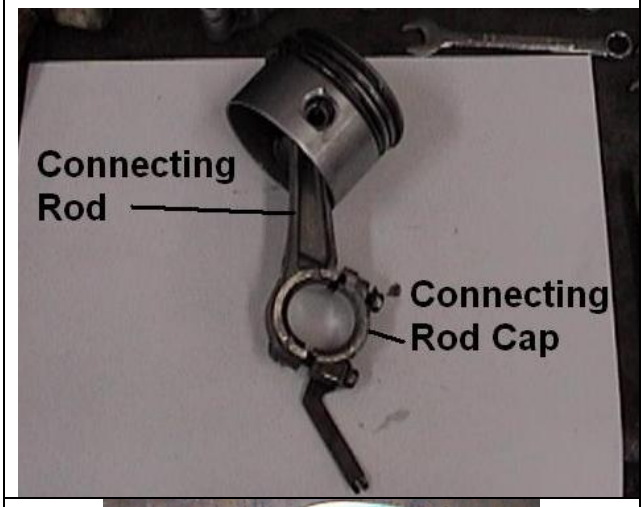
	CAUTION: **There is a "key" (a tiny rectangular piece of metal) that is between the shaft and the flywheel. Do Not Lose This (Tape it right to your storage box)**	

Step	Action: Remove the Muffler & Breather	
12	**Muffler**: A muffler reduces the noise of the engine. **(7/16 socket)** Remove the muffler by using a socket wrench. There are 2 bolts to remove on the muffler.	
13	**Crank Case Breather:** This allows air into the crankcase. Remove the two screws holding the crank case breather	

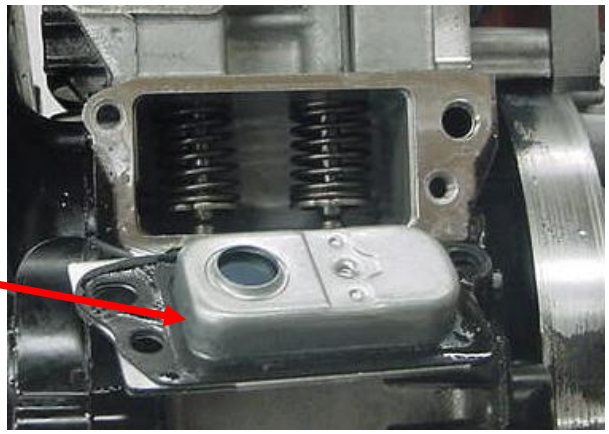
Step	Action: Remove Cylinder Head	
14	**Cylinder Head:** A. The bolts have to be removed so they can be put back in the same hole. Make a template of the cylinder head out of cardboard. B. Loosen each bolt and place each bolt securely in the hole of the template as you remove it. C. Remove cylinder head D. Leave the gasket in place, or if it is loose, put it somewhere so that it doesn't get damaged. E. **The Gasket**: This creates a seal that creates a tight compartment for combustion. If the seal is broken, the engine loses compression and it will not run. Usually, you have to replace the gaskets each time you take an engine apart (unless your careful not to rip it)	  

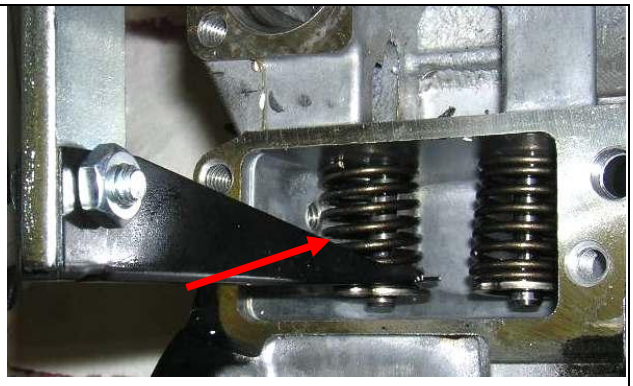
Step	Action: Remove Timing Cover	
15	**Timing Cover:** Remove 7 bolts holding the timing cover. **(3/8 socket)** Remove timing cover (it might need a tap from a soft hammer)	
16	**The Governor Mechanism:** The governor mechanism is the first thing to be removed. It is fitted over top of the camshaft. This mechanism regulates the engine speed through the governor arm that is connected to the throttle. Also, it is used to splash the oil for lubricating the engine parts **Governor Arm**	
17	**Cam Shaft:** Pull out the cam shaft using your fingers Note: the two (2) lifters will drop out	

Step	Action: Remove Piston
18	**Connecting Rod:** Remove two connecting rod bolts. Remove connecting rod cap. It may need a slight tap with the **handle** of a hammer. **Take note of the way the piston is positioned** **The Piston:** The Piston moves up and down to compress the gases in order to create combustion. The rings around the outside keep gases from passing by the piston causing the engine to lose compression. Push the piston UP through the cylinder and remove from the engine. It will be stiff moving it.



Step	Action: Remove Crankshaft
19	**Crank Shaft:** The crankshaft is rotated by the movement of the piston. The energy is transferred to the wheels and/or the blade of the lawnmower. Remove the crank shaft by pulling it straight out.

Step	Action: Remove Valves & Springs	
	Use Safety Glasses for this step. Remove the **Breather Cover** that covers the value springs. Using the valve spring compressor, compress the valve spring and remove from engine as shown	

20	below. Students find this the most difficult step. Be patient. **Value Springs:** The valve springs keep the values in the closed position. With spring compressed, push valve down slightly and you will have to push the compressed spring sideways to release the valve from the lock. Take a look at illustrations below for extra assistance. Slide the bottom of the spring compressor tool between the bottom of the value spring and the stopper. Then tighten the handle on the top of the tool. The tool will start to force the spring up. When the spring is half compressed, you can slide the stopper of the end of the value. Now the value will slide out once the tool is released.	

Assignment 5:

Get a digital camera from the instructor.

Create a PowerPoint made up these 6 components:

1. **Title Page: Small Gas Engines (and a picture of the engine)**

On each page include a name, a picture and an explanation of each part that makes up the system. (Ask how to make a textbox)

2. **The Ignition System: (Pull Chord, Spark Plug, Coil, Flywheel)**
3. **Fuel System: (Fuel Tank, Fuel Line, Carburetor, Valves, Air Filter, Primer Bulb, Muffler) – This will take 2 slides (don't crowd it)**
4. **Cooling System (Flywheel)**
5. **Compression System (Piston, Engine Block, Gaskets, Rings – ask about the rings)**
6. **Mechanical System – (Crankshaft, Camshaft, Governor, Throttle, Engine Brake)**

Assignment 6: Micrometer Lab

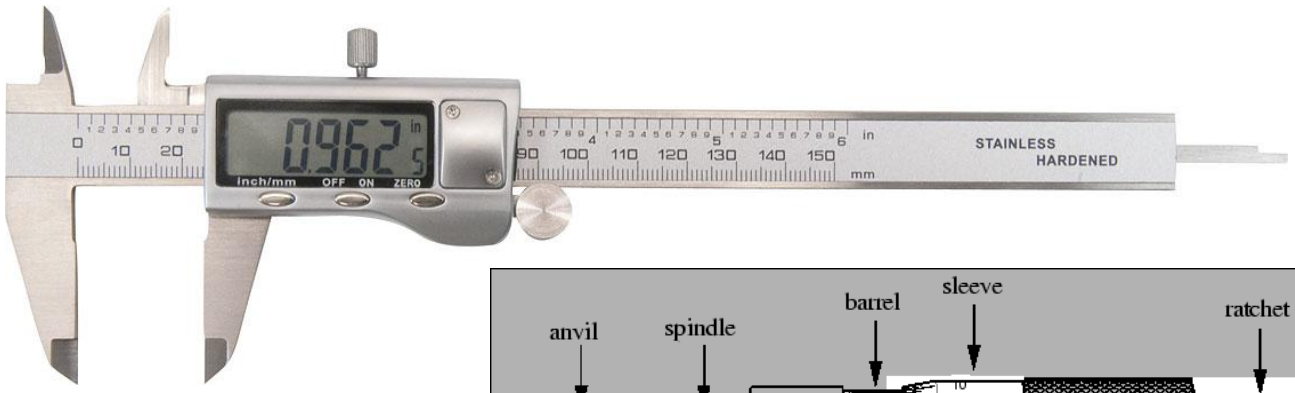
In this lab, you will learn how to measure precisely. Why do we need this? Engines have very little tolerance and just slight wear can cause gaps that lose compression in the engine. We have to measure to the 1/10,000 of an inch.

You will:

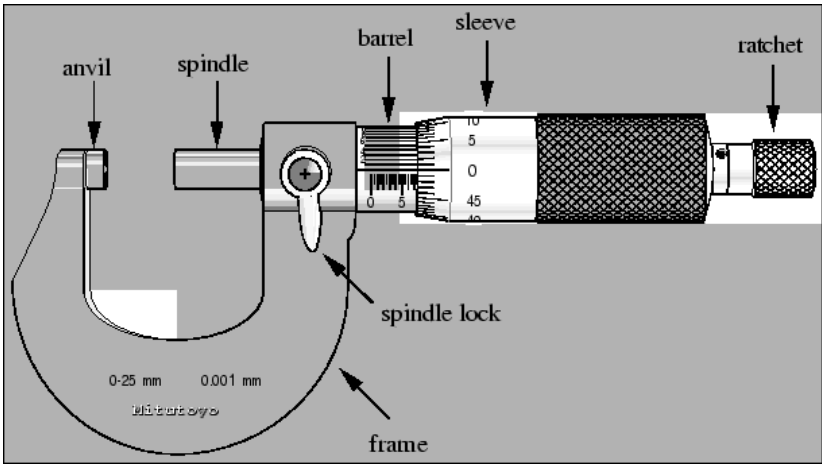
- Learn to read a micrometer from the PowerPoint tutorial
- Measure using Telescoping gauges and a Micrometer.
- Record your answers to the 4th decimal place on the worksheet.

View the PowerPoint presentation on learning how to read a micrometer.

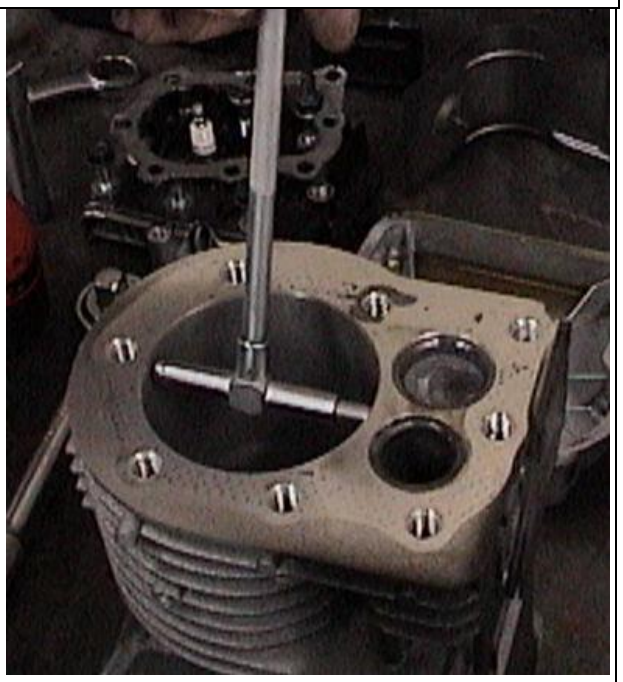
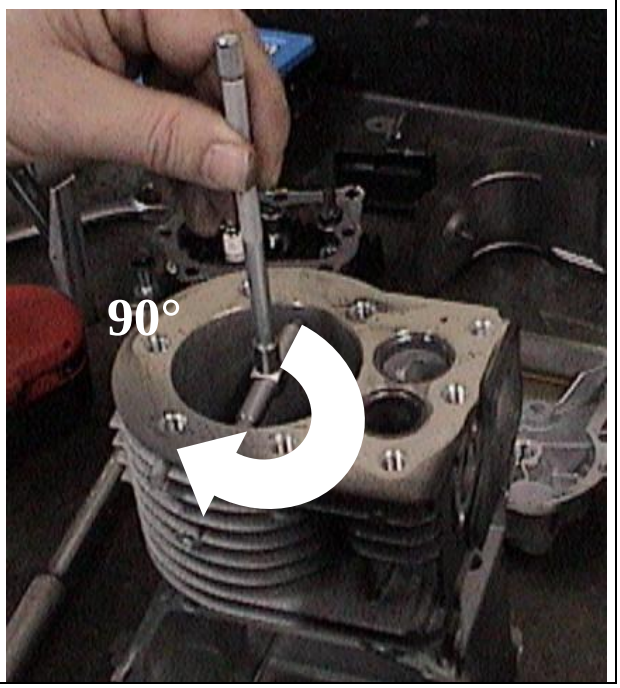
We have two tools to measure precise distances down to 1:10,000 of an inch. The micrometer is the most accurate. Next we have a digital caliper. Find these two tools in your toolbox.



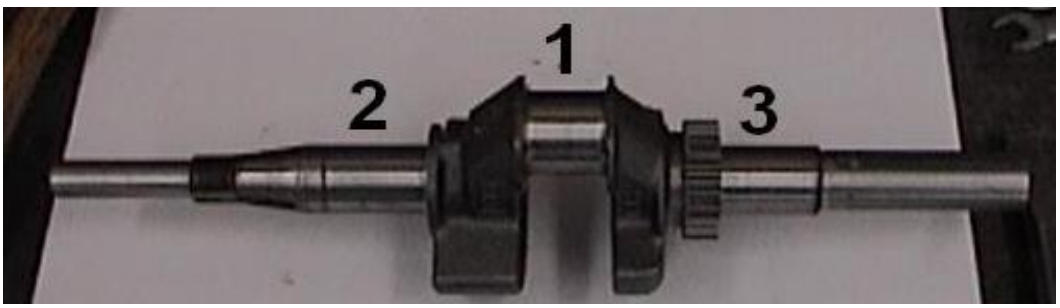
Caliper



Micrometer

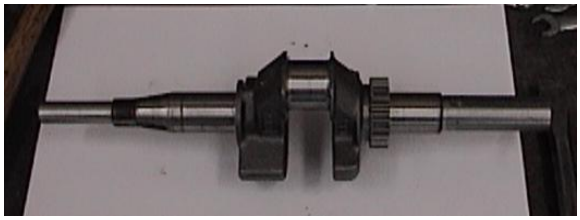
Step	Action: Measure the Cylinder	
1	Using telescoping gauge and the proper sized Micrometer or Caliper (only if you don't have a micrometer that fits). Measure the inside diameter of the cylinder. **Measure every inch (25mm) down the cylinder and again at 90°** Record your meaurements on **your own paper**: 1. _____ 2. _____ 3. _____ 4. _____	
2	Rotate the micrometer 90° and measure again every inch down the cylinder. Record your meaurements on **your own paper**: 5. _____ 6. _____ 7, _____ 8. _____	

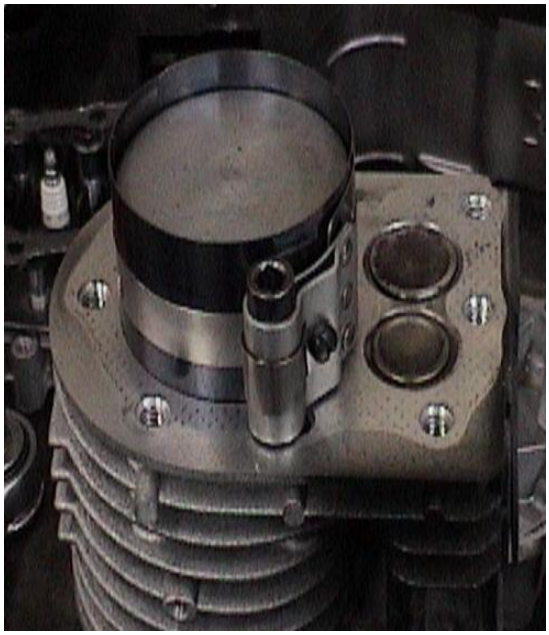
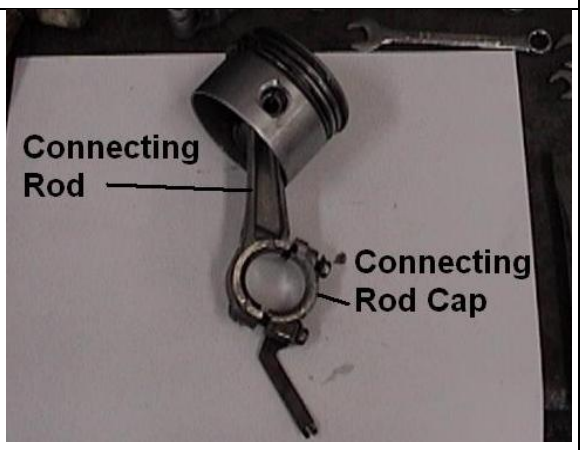
Step	Action: Measure Piston	
3	Measure the piston skirt 9. _____	

Step	Action: Measure Valve Stem	
4	Measure valve stems for wear 10. _____ 11. _____	
5	Measure the three journals on the crankshaft. **1**. Connecting Rod Journal - 12. _____ **2**. Flywheel Journal - 13. _____ **3**. PTO Journal - 14. _____ 	

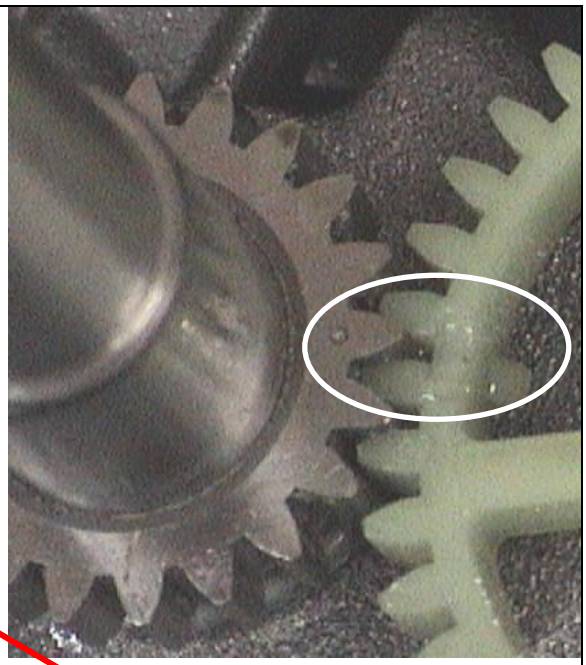
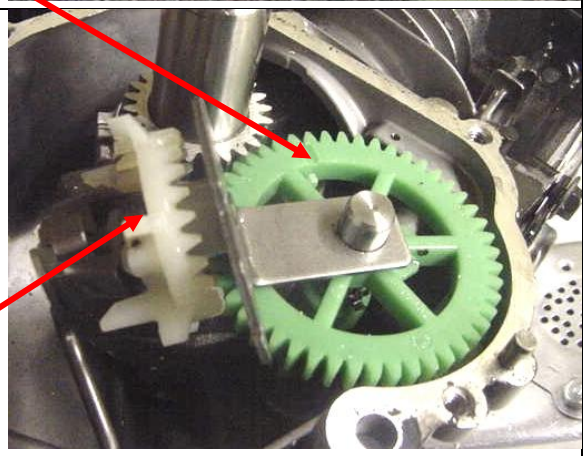
Assignment 7:

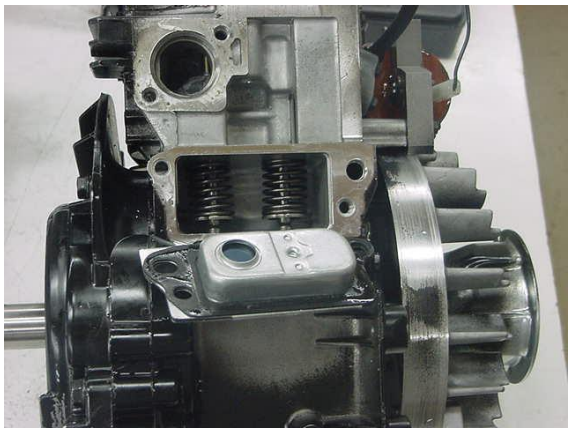
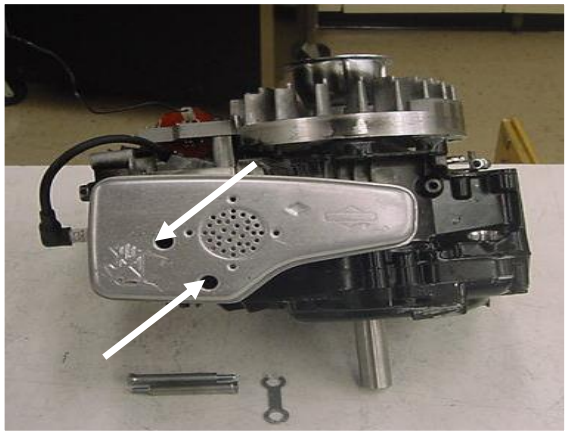
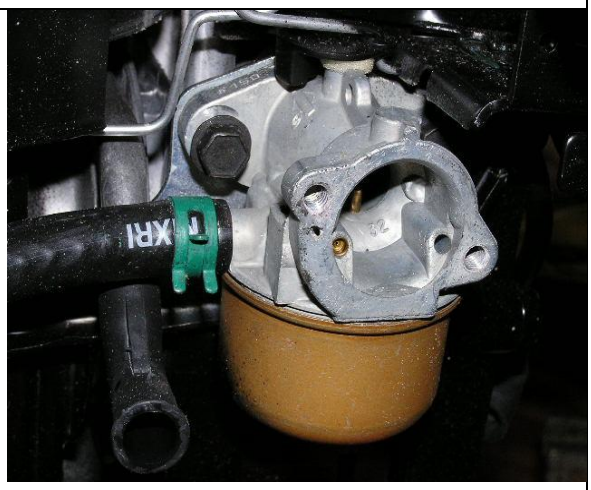
Reassemble the engine using the following directions.

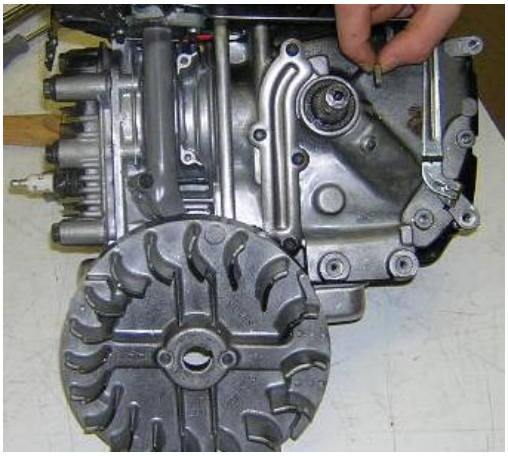
1	Normally, we would lubricate cylinder and valve stems with white grease, **but we won't be doing this today.**	
2	**Valve Springs:** Insert the valves (if they are too long, then you put the wrong one in the wrong hole). Put the spring on the end of the value rod. Use the compression tool to compress the spring about half way. Then, drop the stopper on the end of the valve shaft. **Don't forget your safety glasses.**	
3	**Crankshaft:** Insert the crankshaft (Make sure it is in the right direction)	

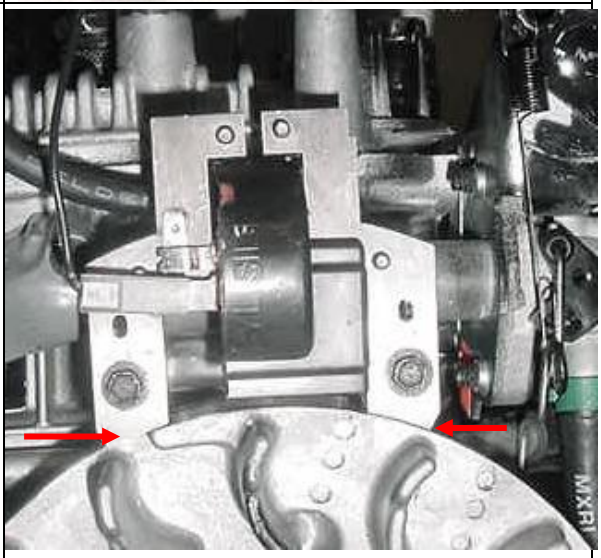
4	**Piston:** You will have to use a piston ring compressor to enable the piston to be inserted into the cylinder. Tighten the compressor so that the bottom of the piston is still visible. Then put the piston in the cylinder hole and lightly tap the piston down into the cylinder (through the piston ring compressor) with the handle of a hammer. Check to make sure that the bottom of the piston rod is lining up with the crankshaft. Put on the rod cap and tighten the bolts as describe in the next step.	
5	**Normally** we would use an inch/pound torque wrench to tighten the connecting rod cap bolts to **100 inch/pounds** torque, however this will just strip the bolts so **only tighten them to 30 pounds.**	

Step	Action	
6	**Lifters:** Stick the lifters in the hole. These are located inside the crankcase. (They look similar to the values but they are smaller – they raise the lifters at the proper time)	

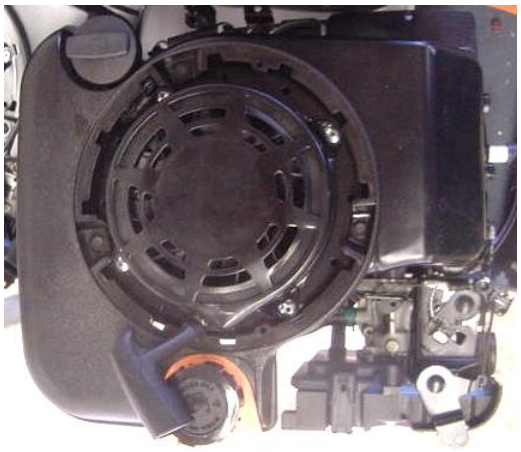
7	**Camshaft:** Install the camshaft, ensuring that the timing marks are aligned according to the picture. **Failure to do so will cause serious engine damage!!**	 **Camshaft**
8	**Governor Mechanism**: Reinstall the governor mechanism but make sure that it lines up with the timing cover and that it is in contact with the governor.	 **Governor**
9	**Timing Cover:** Install timing cover gasket and timing cover. Tighten bolts in a **star** pattern normally to **30 inch/pounds using a torque wrench)**	

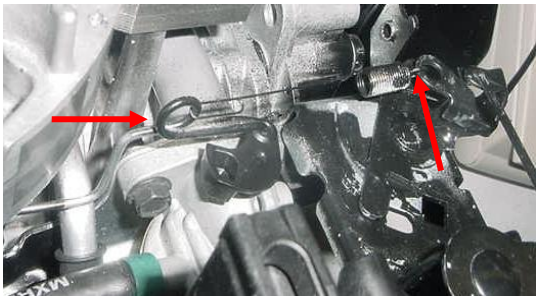
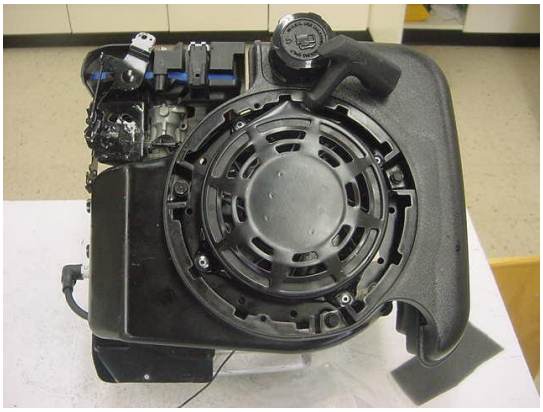
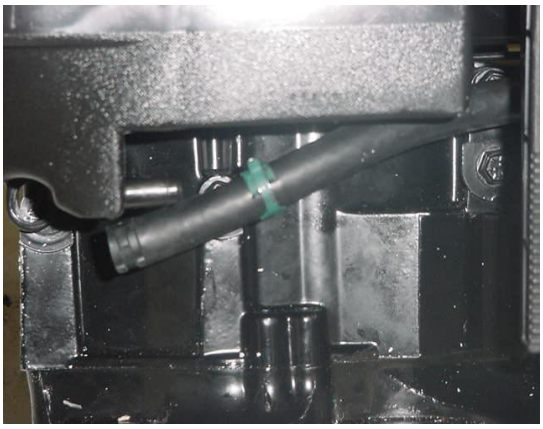
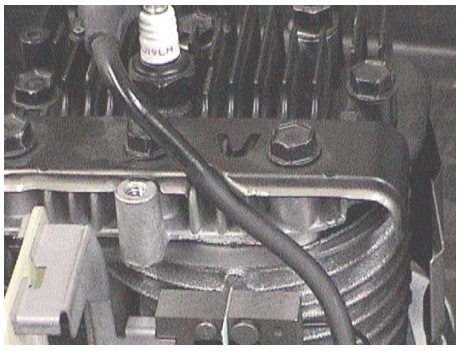
10	**Breather:** Install the breather cover	
11	**Muffler:** Install the muffler	
12	**Carburetor:** Install carburetor assembly and attach breather pipe to carburetor.	

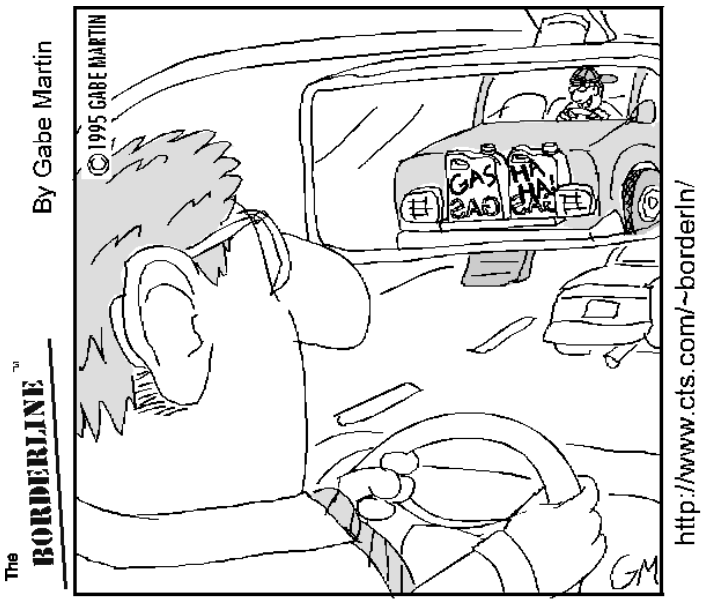
13	**Flywheel:** Install flywheel and flywheel key. **Are you sure the key is installed?**	

Step	Action	
14	**Engine Break:** **We will probably leave the break off so we can test the engine later.**	
15	**Coil:** Install the Coil but leave both bolts loose. Insert a .010" feeler gauge between the flywheel and the coil to get the correct gap. Hold feeler gauge with one hand and rotate the flywheel clockwise until the magnet in the flywheel pulls the coil assembly down towards it. Tighten the bolts. Turn flywheel clockwise to remove the feeler gauge.	

16	**Cylinder Head Cover:** Install head gasket to match bolt pattern. Then, Install cylinder head. Normally, we tighten cylinder head bolts to **140 in/lbs** torque following the proper torque sequence, however, **we will only hand tighten to 30 pounds so we don't strip them.** Make sure the gasket is in place.	

Step	Action	
17	**Starter Cover:** Install starter cover.	
18	**Breather:** Install the breather assembly, the air filter (with the "fins" pointing up), and the breather cover.	

Step	Action	
19	**Governor Wire:** Connect the small rod connecting the carburetor to the governor. Connect the spring that runs from the rod to the throttle as well.	
20	**Oil Dip Stick:** Insert the dip stick into the whole and secure with one screw **(5/16 socket)** **Fuel Tank:** Install fuel tank **(5/16 socket)**	
21	**Hoses:** Connect all hoses	
23	**Sparkplug & Wire:** Install spark plug into cylinder head and tighten to forty **(40) in/lbs torque**. Attach the sparkplug wire to the spark plug.	



After Steve moved the cans to the front of his truck, he never again had problems with people getting in his way.

(Copyright License, The Borderline Cartoon Archives, Internet, http://www.nevtron.si/borderline/publish/licens.html)

Gasoline Safety:

Here are four issues related to gasoline. Read them and propose a solution:

To prevent this in small airplanes, they refuel by keeping the nozzle in contact with the metal fill hole to equalize static electricity (called grounding the nozzle).

Issue 1: Plastic Truck Liners

Several fires have occurred from filling gas cans in the back of pickup trucks with plastic liners. **Why?**

Gasoline tends to carry a static electric charge. When pouring gasoline into a can, this charge can build up on the can. If the can is sitting on concrete or the ground, the static charge can safely flow away. But when the can is sitting on plastic, such as the plastic bed liner in a truck, the static charge cannot escape because the plastic is an insulator, that is, it does not conduct electricity. A spark can occur between the can and the fuel nozzle and ignite the gasoline. Both metal (most hazardous) and plastic gas containers have been involved in these incidents.

("Filling Gas Cans Safely", National AG Safety Database, Internet, http://www.cdc.gov/nasd/docs/d001501-d001600/d001589/d001589.html)

Issue 2: Exhaust Hazards

Exhaust fumes are the product of combustion. They consist of carbon monoxide and other gases. Carbon monoxide crowds oxygen out of the blood stream and starves the body of oxygen. In other words, the body suffocates.

Solution?

Issue 3: Spills and Vapor - Wow!!

American spill 17,000,000 gallons (over 75,000,000 liters) of fuel each year while filling lawn mowers and other outdoor equipment.

Vapors escaping from gas cans account for about 87 tons a day of smog-forming pollution. That's equal to emissions from about 1 million cars.

Solution?

Issue 4: Fires

There were 4,700 gasoline fires in U.S. homes in 1998.

Solution?

Assignment 8: Fuel Safety Issues

After reading the 4 safety issues, complete the worksheet. (Use common sense!)

Find the closes fire extinguisher in your school (where is it? – You should know!). Let your teacher know whether it is rated for a gasoline fire.

Other Ways of Preventing Injury from Gasoline

(NFPA Fact Sheet: Gasoline Safety, Internet, http://www.smyrnatn.org/fire/GasolineSafety.htm)

- √ Change your clothes immediately if you get a gas or oil spill on them (it may catch fire or irritate your skin)
- √ Be careful of empty gas container, they still contain explosive vapors (the vapor is the most explosive element)
- √ Store gas containers in well ventilated areas (not in a house or in the trunk of a car)
- √ Label all fuel containers (Gasoline cans should be Red and Diesel cans Green)
- √ Let equipment cool for a couple of minutes before refueling
- √ Wipe up spills or let evaporate before starting the equipment
- √ Never use your mouth to siphon fuel (gasoline or diesel in your lungs can be fatal)
- √ Refuel away from a building
- √ Don't use gasoline as a cleaning agent
- √ Store oily rags in a metal container
- √ **Always** have a fire extinguisher marked for "B" type fires (Gasoline and other flammable liquids) – Never use water, it will splash the gasoline and make the fire spread
- √ Always remove the gas cans from inside your vehicle before filling it.

Assignment 9: Fuel Safety Quiz

Make sure you know the safety points above, then answer the quiz questions on the worksheet.

Gasoline Safety Quiz

1. What is the standard color of a gas can?

a. blue
b. green
c. red
d. orange

2. What is the standard color of diesel cans?

a. blue
b. green
c. red
d. orange

3. What rating on a fire extinguisher indicates that it would be used for gasoline fires?

a. A
b. B
c. C
d. D

4. The job is not done but the mower is out of gas. What should you do before filling it?

a. Let the engine cool for 2 minutes or more
b. Empty the grass
c. Remove the spark plug wire
d. Fill it up so you can get the job done

5. Using water is not a good way of extinguishing a gas fire because:

a. It will evaporate too quickly
b. It might not be available all the time
c. Water could become contaminated with gas and since into the soil
d. Water will splash the gasoline and spread the fire to other areas

6. The most dangerous gas cans:

a. Are almost empty – the rest is gas vapors
b. Are made of metal
c. Are made of plastic
d. Are completely full

7. Fires involving plastic gas can stored on the plastic truck liners begin because:

a. They can slide around
b. Metal or Plastic gas cans on plastic retain static electricity that can produce a spark
c. Plastic gas cans are not safe
d. They might tip over

8. Never refill an engine in a building because:

a. You need good ventilation
b. The building could burn down if the fuel ignites
c. The fumes are dangerous to inhale over a long period of time
d. All of the above

9. We can reduce gasoline hazards by having:

a. A good understanding of safety procedures
b. Using gas cans that don't allow gas vapors to escape
c. Using gas cans with spill proof tops
d. All of the above

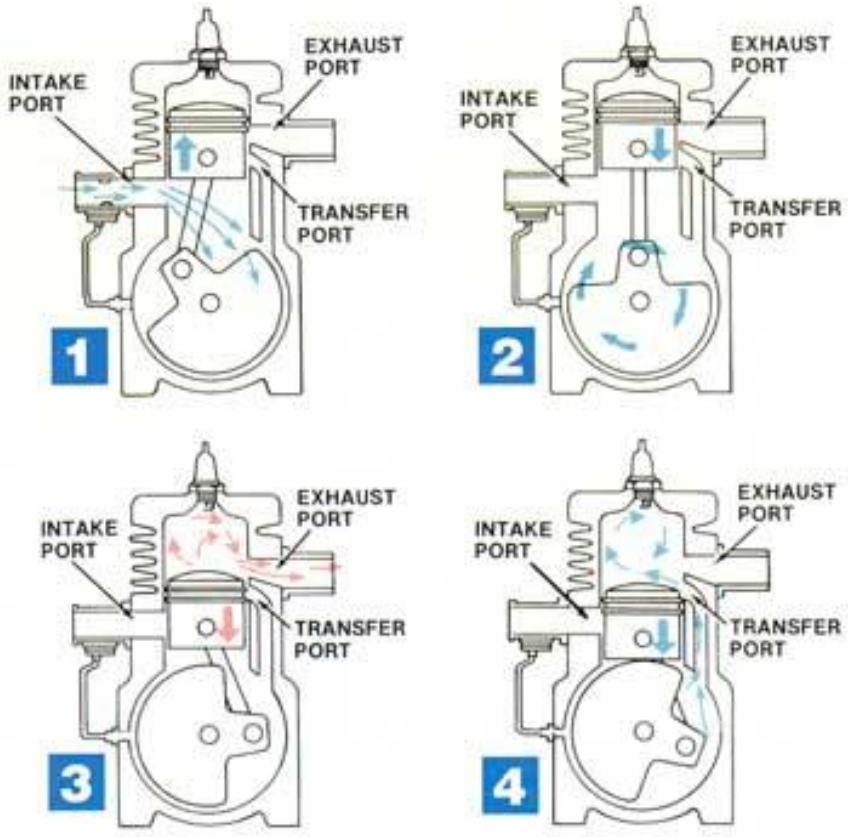
10. If you get gasoline on your clothes:

a. Change them immediately – they may catch fire
b. They could burn your skin
c. Store rags in a metal container
d. All of the above

Two or Four Stroke?

Engines are either **two stroke** or **four stroke (you can substitute the word Cycle for Stroke. i.e. Two Cycle)**. The stroke is the movement of the piston from BDC (bottom dead center) to TDC (top dead center). The engine components work slightly different depending which it is.

Two-Cycle Engine



In a two-cycle engine, the piston completes the **intake** and **compression** stages in the single stroke. On the second stroke of the two-cycle engine, the **power** and **exhaust** stages are completed. This is all accomplished in one 360° rotation of the crankshaft. This allows for the two-cycle engine to accelerate much faster than the four-cycle engine.

Two Stroke engines are commonly associated with engines that require the oil to be mixed with the gas.

How a two-cycle engine works:

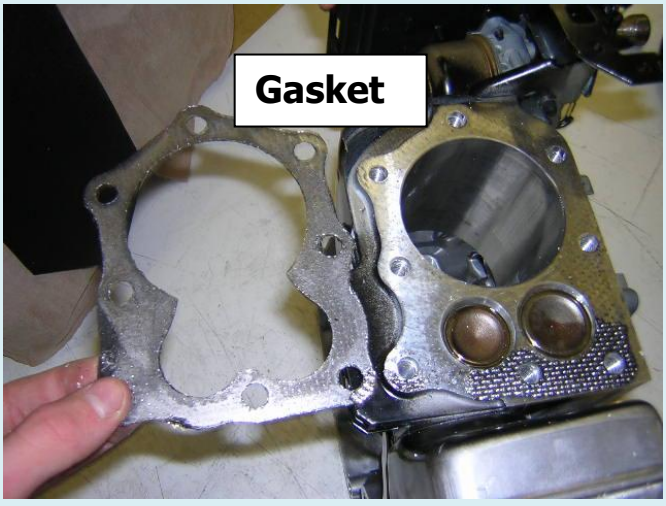
(You will need this information later to fill in the two-stroke chart)

Take a look at the diagram of the two-cycle engine from the web site as you read how a two-cycle engine works.

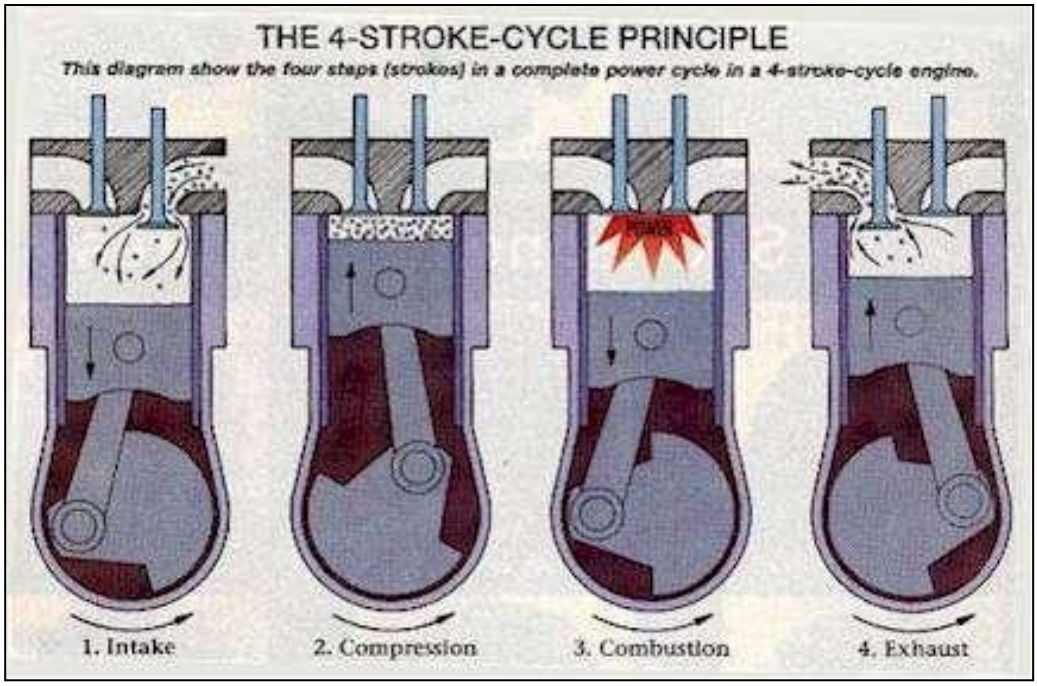
- As the piston moves from BDC (bottom dead center) toward TDC (top dead center), a low-pressure area is created in the crankcase, which causes the air/fuel (oil) mixture to be drawn into the crankcase. At the same time, the air/fuel (oil) mixture above the piston is being compressed into the combustion chamber.
- Just before the piston reaches TDC (top dead center), the spark plug ignites the air/fuel (oil) mixture, forcing the piston down. This creates a high-pressure area in the crankcase. This high-pressure stops any more air/fuel (oil) mixture from entering the crankcase.
- As the burning gases expand, power is transferred from the piston to the crankshaft.
- As the piston moves down in the cylinder, the exhaust port is the first to open. This allows the burning air/fuel (oil) mixture to escape into the exhaust system.
- A little further down the cylinder, the intake port opens. This allows the pressurized air/fuel (oil) mixture in the crankcase to force into the cylinder, which pushes any remaining burnt fuel out into the exhaust system.
- The piston then starts to move back up the cylinder from BDC (bottom dead center) starting the process all over again.

Two Cycle and Four Cycle Engines

Because of the importance of air pressures in a two-stroke engine, it is essential that all seals and gaskets do their job. If there were a leak in one of the seals or gaskets in the crankcase of a two-stroke engine, the engine would draw air through the seal (gasket) and into the combustion chamber instead of drawing the air fuel mixture.



Four-Cycle Engine


THE 4-STROKE-CYCLE PRINCIPLE
This diagram show the four steps (strokes) in a complete power cycle in a 4-stroke-cycle engine.
1. Intake
2. Compression
3. Combustion
4. Exhaust

It takes two full rotations of the crankshaft for all four engines cycles to occur, therefore, it is slow to accelerate than a 2 cycle engine. These engines have oil separate from the gas, just like a regular car engine.

How a 4 Stroke Engine Works:

1. On the down stroke, the intake valve is opened and the fuel/air mixture is drawn into the combustion chamber.

2. On the upstroke, the intake valve has closed and the fuel/air mixture undergoes compression.

3. Ignition takes place by means of the glow plug (not shown); the fuel/air mix explodes, and the piston is forced down for the second time in the cycle. This is called the "**power stroke**".

4. The exhaust valve is open and the piston moves up for the second time in the cycle, and the burned gases are expelled out through the exhaust valve into the muffler.

Assignment 10:

Fill in the columns on the Two & Four Cycle Worksheet. Use the information and diagrams to assist you.

Assignment 11: Maintenance

You can avoid many small engine problems and prolong the life of your engine if you follow a **regular** maintenance schedule. Always consult your owner's manual for special instructions.

Using your ***Small Engine Care & Maintenance*** book (page 43), complete the Maintenance Schedule Worksheet.

Fuel and Lubrication

Fuel & Lubricants (Gas & Oil)

Gasoline is a mixture of hydrogen and carbon (a hydrocarbon fuel) that contains a great amount of energy. Gasoline that is used in engines must:

- Be Clean – free of dirt, water and abrasive particles
- Be able to ignite readily, burn clean and resist violent explosion (detonation) without an external source of ignition

Gasoline is available in different grades. Some of the more common grades are regular (low) and premium (high). Some petroleum companies offer a mid-grade option as well. The major difference between these grades is the **octane** level. The octane level is the gasoline's ability to resist detonation. The lower the octane number, the faster the gasoline will burn therefore, regular grade gasoline is used in low compression, small engines. Premium gasoline contains a higher level of octane and therefore burns slower. Premium grade gasoline is typically used in high compression engines.

Two-Stroke Engine Lubrication Systems

From reading above, you have learned that in a two-stroke engine the fuel that is burnt contains oil. The reason for this is *lubrication*. ***Lubrication*** is the process of reducing *friction* between sliding surfaces by introducing a slippery or smooth substance between them. ***Friction*** is the resistance to motion created when one dry surface rubs against another. Automotive engine oils are not suitable for two-stroke, air-cooled engines because air-cooled engine operation covers a wider range of varying speeds as well as much higher combustion chamber temperatures. Automotive engine oils contain additives that do not burn completely and leave a residue that fouls spark plugs and can clog exhaust ports. Two-stroke engine manufacturers recommend the use of diluted, two-cycle engine oil.

There is basically two ways that a two-stroke engine can be lubricated: (1) by pre-mixing the oil with the gas and, (2) through oil injection (commonly used in snowmobiles, personal watercraft, and dirt bikes).

(1) **Pre-mixing oil and gas** – by pre-mixing the oil and gas together at the specified oil-to-fuel ratio stated by the manufacturer, the two-stroke engine will be supplied with sufficient lubrication. It is very important to know the specified ratio for the particular engine because having to much oil will create a lot of smoke, foul the spark plug, decrease power output and clog exhaust ports. In operation, an oil mist is created that lubricates the cylinder wall and all internal engine parts.

(2) **Oil injection** – in oil injection systems the oil is NOT pre-mixed with the gas. The oil is placed in a separate tank (usually in a location higher than the engine) and is then either fed to the carburetor by either gravity or with the assistance of an oil pump. The oil is then mixed with the gas and air in the carburetor and proceeds to lubricate the internal parts of the engine in the same manner as the pre-mixed method. Oil injection systems are not suitable for all two-stroke engine applications such as power chain saws and lawn trimmers as these devices can be operated in many different positions.

Four Stroke Engine Lubrication Systems

The oil that is stored in the crankcase lubricates four stroke engines. Using too much oil, or oil of the wrong grade can cause the engine serious damage. There are a number of methods of which four-stroke small engines can be lubricated. The two most common are the splash system or the pump system.

The splash system lubricates the engine through the motion of the crankshaft in addition to a splash finger that is connected to the connecting rod cap that dips down into the oil and then deflects it throughout the crankcase. The pump system picks up the oil and circulates it through an oil filter to clean it and circulates some through a spray nozzle pointed at the crankshaft. While the shaft rotates, it deflects oil throughout the crankcase. Engine oil is also pumped through a tube to the governor assembly as well as through the connecting rod to lubricate the bearings and piston pin. Four-stroke engines must be operated in an upright position because oil would drain away from the pump or splash finger-preventing lubrication.

Checking the oil

Two and four stroke engines require different oils. For two-stroke engines, special oil must be mixed in proper proportion with the gasoline:

- Use only fresh unleaded gas. Gas that is over a month old may result in hard starting.
- The proper amount of oil is critical to the happiness of your engine. Too little and it may overheat, cause excessive wear, and in extreme cases (but not unusual), cause engine parts to seize and fail - **very expensive!**
- Make it a habit to check the oil regularly. Doing this after about every 5 hours of operation is generally recommended. Old dirty oil will shorten the life of your engine and affect its starting and running performance eventually. Change it after 25 hours.
- Oil should be checked when the engine is cold or after waiting 10 minutes for it to drain back into the oil sump after running the engine.
- Although small engine manufacturers may recommend SAE 30 oil, they usually also state that 10W-30 or 10W-40 are acceptable substitutes
- Place the mower on a level area so you get true reading
- If the oil level is high, drain enough oil to bring the level back down to the full mark. Too much oil can result in problems as well.
- If the oil is very low, there may be a leak or your engine may need a ring job. Excessive oil under the deck - on the shaft or blade adapter - would indicate a bad bearing or oil seal. Noticeable blue smoke while running would indicate that excessive oil is getting by the rings into the combustion chamber.
- Since there is typically no oil filter, all the grit, metal particles, and other undesirable stuff continues to circulate with the oil to find its way in between precision engine parts.

Additional instructions for Two Stroke Engines:

- For 2 stroke engines, you must mix the proper amount of the correct two-stroke engine oil. Slosh it around, with the cover on, to mix it up.
- The ratio of gas to oil in a two stroke engine typically ranges from 16:1 to 32:1 gasoline:oil by volume – check your manual to be sure.

Assignment 12: Fuel & Lubrication Quiz

Read the section "Checking the Oil" and answer the multiple choice questions on your own paper.

Assignment 12 Quiz: Fuel & Lubrication

(Answer on the worksheet)

1. What does oil do for an engine?

   a. Reduced friction between moving parts
   b. Cools the internal parts of the engine
   c. Reduces wear on the parts
   d. All of the above

2. Which engine type requires oil to be mixed into the gas?

   a. Two Stroke Engines
   b. Four Stroke Engines
   c. Car Engines
   d. Diesel Engines

3. Using old gas can prevent your engine from starting. How new should gas be?

   a. Less than 1 month old
   b. Less than 6 months old
   c. Less than 1 year old
   d. Less than 6 years old

4. The ratio of gasoline to oil in a two stroke engine is usually around:

   a. 50:1
   b. 1:50
   c. 1:32
   d. 32:1

Example: 50:1 means: 50 units of gas to 1 unit of oil

5. How can you tell what the **proper** fuel to oil mixer should be?

   a. Just guess
   b. Try a little at first, then add some more
   c. Check in the manual or look on the engine
   d. Make sure there is enough smoke coming out the exhaust

6. What will happen to your engine if there is too little oil?

   a. The engine will seize
   b. The engine may overheat
   c. Causes wear on the internal parts of the engine
   d. All of the above

7. Usually four stoke engines don't burn much oil. However, how often should you check the oil?

    a. Every year
    b. Every 5 hours of engine operation
    c. Every 25 hours of engine operation
    d. Every 40 hours of engine operation

8. There is no oil filter on a four stroke engine so tiny particles circulate with the oil. How often should the oil be changed?

    a. Every year
    b. Every 5 hours of engine operation
    c. Every 25 hours of engine operation
    d. Every 40 hours of engine operation

9. When should you check the oil reading on the dipstick of a four stroke engine?

    a. Check when the engine is running
    b. Check when the engine has been off at least 10 minutes
    c. Check as soon as the engine has been turned off
    d. All of the above are OK

10. What problem can too much oil have on an engine?

    a. No problem – better too much than too little
    b. The increased pressure can cause it to make its way into the cylinders and cause problems
    c. It may pop the oil cap off the engine
    d. All of the above

Assignment 13: (Optional/Enrichment)

A lot of things are happening simultaneously in the two-cycle engine. Visit the following website for further explanations and animations:

http://science.howstuffworks.com/two-stroke.htm

Go to the site mentioned above and click on the link “two stroke basics” . Look at the diagram and the explanation.

1. List the three advantages of a two-stroke engine over a four-stroke engine.

Now, type Horsepower in the Search Box in that site

2. Who invented the term horsepower?
3. What else was this guy famous for (2 things)?
4. Explain the meaning of the word horsepower as it relates to the amount of work done.
5. Find the amount of horsepower for the engine that you are working on.
6. What kind of instrument is used to measure horsepower?
7. What does this instrument do?

From the information written in this section of the module book, answer this question.

8. What is the problem if the gasket that seals the parts together gets a tear in it?
9. What is the difference between the terms, “a two-stroke engine” and “a two-cycle engine”?

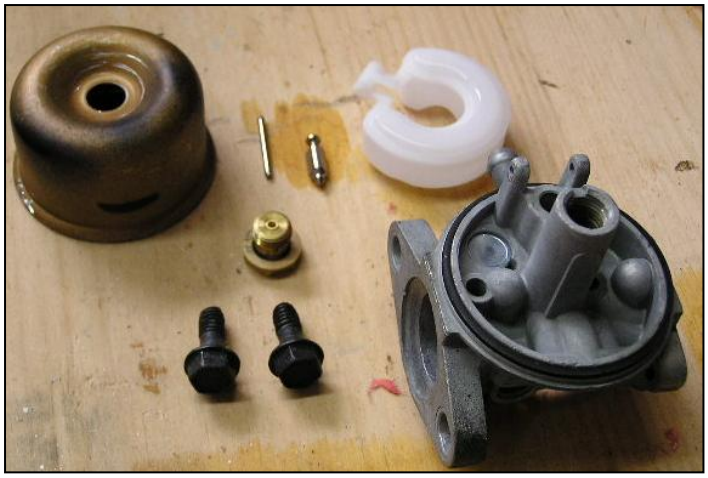
In a four-cycle engine, each stage has its own stroke of the piston. As the piston moves from TDC (top dead center), to BDC (bottom dead center) the intake stroke occurs. As the piston moves from BDC (bottom dead center) to TDC (top dead center) the compression stroke occurs. As the piston then moves again from TDC (top dead center), to BDC (bottom dead center) the power stroke occurs, and finally as the piston moves from BDC (bottom dead center) to TDC (top dead center), the exhaust stroke occurs. Then the process starts all over again. It takes two full rotations of the crankshaft for everything to happen in the four-cycle engine.

Assignment 14: Carburetion
(Optional/Enrichment)

Gasoline engines cannot run on liquid gasoline alone. The liquid gasoline must be mixed with air in the proper proportions for an engine to run and this is done so in the carburetor. Carburetors are specially designed to provide smooth engine operation and economical fuel consumption at the varying engine speeds.

Carburetors mix the gasoline and air to provide for an engines various operating conditions such as:

- Hot or cold starting
- Idling
- Part throttle
- Acceleration
- High speed operation



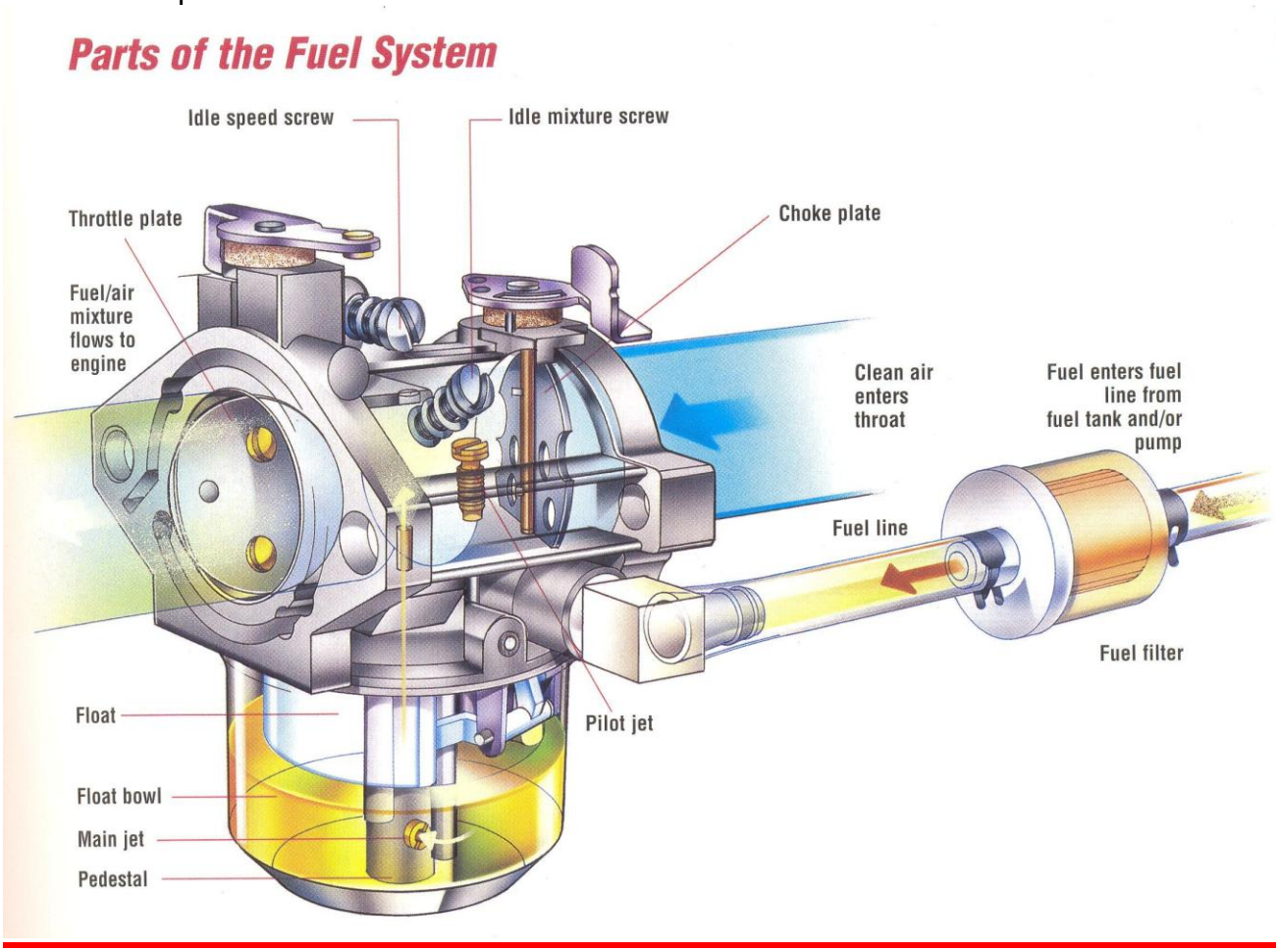
The principle of operation of the carburetor is that air enters the carburetor either though the top, bottom or side (depending on the type of carburetor) and is mixed with liquid fuel. The liquid fuel is fed through passages in the carburetor and sprayed into the air stream. Atmospheric pressure and the vacuum that is created in the cylinder during the intake stroke draw the air/fuel mixture into the combustion chamber.

Often when an engine won't start it is due to the carburetor being plugged with dirt or with varnish from old gas. This can be fixed by using a spray that dissolves the dirt, or by taking the carburetor apart and using compressed air to blow it out. **Be careful not to lose the small parts**.

If available, watch the Briggs and Stratton Video on Carburetors (15 minutes) and answer these questions (or Google the questions):

1. What is the purpose of a carburetor?
2. What is the role of the Venturi?
3. What does a throttle plate control?
4. What does the primer do?

Take a look at the parts of a fuel system on the next page and become familiar with the name of the parts.



Assignment 15: Ignition Systems (Optional/Enrichment)

The ignition system of the small gasoline engine provides the electrical voltage to discharge a spark across the gap of the spark plug to ignite the air/fuel mixture in the combustion chamber. The spark must fire at exactly the right time in order to ignite the mixture and produce the power for the power stroke.

In a two-cycle single cylinder engine, operating at 3200 revolutions per minute (RPM), the ignition system will fire 3200 times per minute. A four cycle single cylinder engine operating at 3200 RPM will fire only 1600 times per minute.

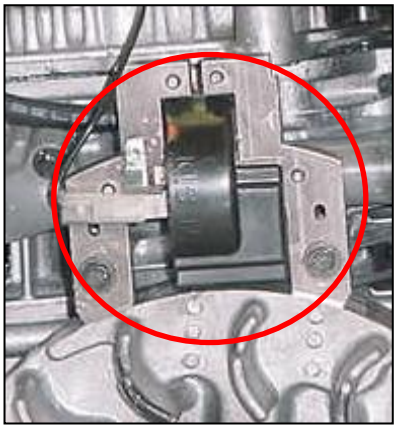
Most small gasoline engines use a ***magneto system*** to supply the ignition spark. The major benefit of using a magneto system is that it does not require an outside primary source of electricity to produce the electrical spark. Two of the more common magneto systems used on small gas engines are the ***mechanical breaker ignition (MBI)*** **system** and the ***solid state*** **ignition system**. The MBI ignition system uses mechanical breaker points to control current in the ignition coil. A *solid state* ignition system is any ignition system that uses electronic components to control the current in the ignition coil.

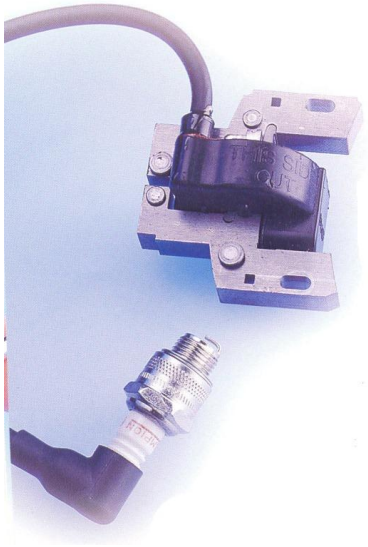
Mechanical Breaker Point Ignition (MBI) Systems

Mechanical Breaker Point Ignition (MBI) Systems were used on small gas engines until about the mid-eighties and there are still lots of small engines around that have them. Breaker point ignition systems use a mechanical switch to control the timing of the ignition.

Capacitive Discharge Ignition (CDI) Systems

A Capacitive Discharge Ignition (CDI) System is a solid-state ignition system made of electronic semi-conductors (diodes, transistors, silicon controlled rectifiers, etc.) in place of the mechanical points and accessories found in a mechanical breaker ignition system. The CDI system is a compact and sealed unit that has no moving parts other than the flywheel magnet therefore there is no need for maintenance. It is standard equipment on most small engine applications today and has greatly improved the reliability of these engines.





Whether you turn a key or pull a pull-chord, you rely on the ignition system to create a spark in the combustion chamber. Refer to ***Engine Care & Maintenance*** book (page 26) to answer these questions.

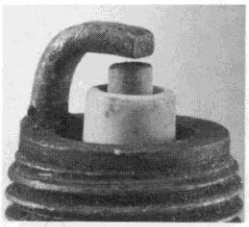
1. As the flywheel turns, what passes the ignition armature to induce electricity that causes the spark?
2. What part in the engine has to be timed with the ignition system?
3. How many volts of electrical current does it take to produce a spark on the sparkplug?
4. Is the current going through the spark plug wire dangerous to a person if they were touching it?
5. What is the main difference between a Breaker Point Ignition and a Solid State Ignition System?
6. What clue would have to whether an engine had a Breaker Point Ignition and a Solid State Ignition System?

Assignment 16: Spark Plugs (Optional/Enrichment)

The spark plug is part of the Ignition System. It has to be in proper condition to work effectively. Regular maintenance determines whether the Spark Plug should be replaced. See the chart on the next page and explain each condition in your own words.

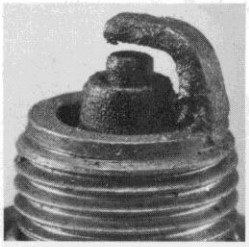
(Source: Roth, Alfred C., Small Gas Engines, The Goodheart-Willcox Company Ltd., Illinois, 1992)

SPARK PLUG CONDITION CHART

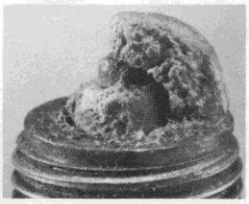


NORMAL APPEARANCE
A spark plug in a sound engine operating at the proper temperature will have deposits that range from tan to gray in color. If LP-Gas is used, the deposits will be brown. Under normal conditions, the electrode should wear slightly, but there should be no evidence of burning.

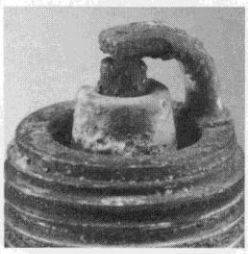
CARBON FOULING
Carbon fouling (dry, black, sooty carbon deposits) can be caused by plugs that are too cold for the engine, an over-rich fuel mixture, a clogged air cleaner, a faulty choke, or sticking valves. Installing a hotter plug will temporarily solve this problem.



OIL FOULING
Oil fouling (wet, black deposits) is caused by excessive oil in the combustion chamber. Worn rings, valve guides, valve seals, and cylinder walls can cause oil fouling. Switching to a hotter spark plug may temporarily relieve the symptoms, but will not correct the problem.

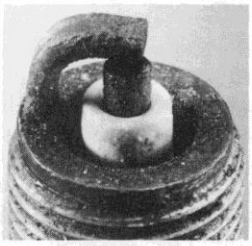


ASH FOULING
Ash fouling is caused by the buildup of heavy combustion deposits. These deposits are formed by burning oil and/or fuel additives. Although ash fouling is not conductive, excessive deposits can cause a spark plug to misfire.

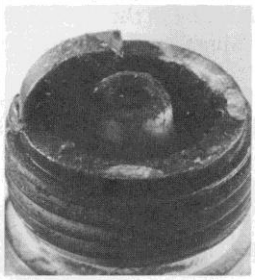


SPLASHED FOULING
Splashed fouling can occur after a long-delayed tune-up. When a new plug is installed in an engine with excessive piston and combustion chamber deposits, the plug will restore regular firing impulses and raise the combustion temperature. When this occurs, accumulated engine deposits may flake off and stick to the hot plug insulator.

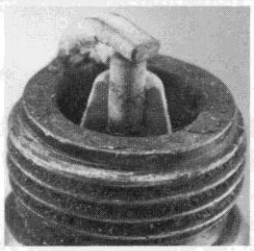
GAP BRIDGING
Gap bridging (combustion deposit bridging the center and ground electrodes) is caused by a sudden burst of high speed operation following excessive idling. It can also be caused by improper fuel additives, obstructed exhaust ports (two cycle engines), and excessive carbon in the cylinder.



HIGH SPEED GLAZING
High speed glazing (hard, shiny, electrically conductive deposits) can be caused by a sudden increase in plug temperature during hard acceleration or loading. High speed glazing can cause the engine to misfire at high speeds. If high speed glazing recurs, a cooler plug should be used.



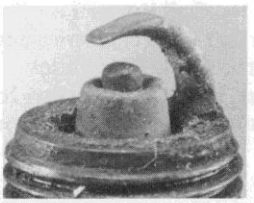
PREIGNITION
Preignition (fuel charge ignited by a glowing combustion chamber deposit or a hot valve edge before the spark plug fires) can cause extensive plug damage. When plugs show evidence of preignition, check the heat range of the plugs, the condition of the plug wires, and the condition of the cooling system.



DETONATION
Detonation can cause the insulator nose of a spark plug to fracture and chip away. The explosions that occur during heavy detonation produce extreme pressure in the cylinder. Detonation can be caused by low octane fuel, advanced ignition timing, or an excessively lean fuel mixture.

OVERHEATING
Overheating (dull, white insulator and eroded electrodes) can occur when a spark plug is too hot for the engine. Advanced ignition timing, cooling system problems, detonation, sticking valves, and excessive high-speed operation can also cause spark plug overheating.

MECHANICAL DAMAGE
Mechanical damage can be caused by a foreign object in the combustion chamber. It can also occur if the piston hits the firing tip of a spark plug with improper reach. When working on an engine, keep spark plug hole(s) and carburetor throat covered to prevent foreign objects from entering the combustion chamber.



WORN OUT
Extended use will cause the spark plug's center electrode to erode. When the electrode is too worn to be filed flat, the plug must be replaced. Typical symptoms of worn spark plugs include excessive fuel consumption and poor engine performance.

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Assignment 17: Final Questions:
(Optional/Enrichment)

Here are a few questions that bring together everything that you have learned:

1. What are the five basic systems that make up a small gas engines?
2. List 10 parts of an engine and describe their function.
3. How important are the gaskets in an engine? Explain!
4. What is the function of a torque wrench and where exactly would it be used for assembling an engine.
5. Draw the bolt pattern for tightening the cylinder head cover.
6. What two things are mixed in the carburetor?
7. What might be wrong with the engine if blue smoke is coming out the exhaust?
8. Why is it dangerous to hold the sparkplug wire while you pull the starter cord?
9. List 8 conditions that could effect the proper functioning of the spark plug.
10. What has to be done to the fuel in a two-stroke engine that doesn't have to be done in a four-stroke engine?
11. What safety function does the engine break perform?